NOTES ON THE COMPOSITION AND STRUCTURE OF THE INDARCH, RUSSIA, METEORIC STONE.

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This interesting stone fell, according to V. Siemaschko, on April 7, 1891, though Meunier [1] gave the date as April 9. According to Wülfing's catalogue the stone has since been described by Tarassow, but seems never to have been subjected to a thorough microscopic or chemical investigation. I have, therefore, included it in the studies on the minor constituents on which I have been engaged.[2]

It is stated by Meunier that in falling the stone buried itself in the soil to a depth of 18 cm. and scorched the vegetation for a radius of 10 meters, being still hot when exhumed 10 hours later. The dark color he regarded as due to the heat to which it had been subjected, and he claimed to have produced similar results in the laboratory on stones of his Montrejeit group.

Macroscopically the stone is of a dark greenish gray color, firm and compact, admitting of a polish, and on the polished surface thickly studded with small, dark, almost black chondrules and nodular masses of metal and troilite, the largest of which are rarely over 1 mm. in diameter. Under a pocket lens the chondrules are mostly of a green color, though some are nearly black. They break with the matrix in which they are embedded. In thin sections and under the microscope the structure is quite obscure owing to the prevalence of graphite, which everywhere impregnates it. It presents a dense black irresolvable ground throughout which are scattered the iron and iron sulphide, together with abundant sharp splinters of pyroxene and numerous more or less fragmentary chondrules of the same mineral in both porphyritic and radiating forms (see pl. 37). All of the well crystallized forms, both in isolated particles and in the chondrules, belong to the polysynthetically twinned clino-enstatite type. No olivine, feldspar, or other silicate mineral was determined, though carefully sought, as their presence was suggested by the

[1] Comptes Rendus, vol. 125, 1897, p. 894.

[2] See preliminary paper, Amer. Journ. Sci., vol. 35, 1913, pp. 509–525.

analysis. The presence of carbonic acid, as shown by the analysis, suggested the mineral breunnerite, but this could not be determined absolutely owing to the obscuring effect of the graphite already mentioned, although the solution obtained by boiling for a few minutes in dilute (1–4) hydrochloric acid reacted distinctly for magnesia. The calcium sulphide, oldhamite, was, however, detected first by chemical means and afterward by the microscope. The mineral occurs in the slide in the form of irregular areas, sometimes interstitial and sometimes inclosed in the enstatite. It is of a yellow brown color, sometimes greenish, completely isotropic, and with well developed cubic cleavage. Attempts at isolation of the mineral failed. Microchemical tests were also rendered futile by the abundant hydrogen disulphide given off when the slide was treated with even the most dilute acid. On boiling 9.35 grams of the finely pulverized stone for one hour in distilled water the solution, smelling distinctly of H_2S, yielded 0.464 per cent CaO, the equivalent of 0.596 per cent CaS.

Analyses of the stone by Dr. J. E. Whitfield yielded the results given below:

Metallic portion separated by mercuric chloride solution.

	Per cent.
Iron (Fe)	90.44
Nickel (Ni)	8.26
Cobalt (Co)	0.18
Phosphorus (P)	0.08
Manganese (Mn)	1.04
	100.00

Silicate portion, free as possible from the metal, sulphides, and graphite, yielded:

	Per cent.
Silica (SiO_2)	47.970
Alumina (Al_2O_3)	2.647
Ferrous oxide (FeO)	19.283
Phosphoric acid (P_2O_5)	0.699
Manganous oxide (MnO)	0.175
Nickel oxide (NiO)	0.739
Cobalt oxide (CoO)	0.067
Lime (CaO)	1.559
Magnesia (MgO)	22.736
Carbonic acid (CO_2)	0.363
Soda (Na_2O)	Trace.
Potash (K_2O)	None.
Water (H_2O)	3.762
	100.00

Independent determinations showed 13.296 per cent of FeS and 0.31 per cent of graphite.

A recalculation of these analyses gives the following, showing the composition of the stone as a whole:

	Per cent.
Silica (SiO_2)	35.699
Alumina (Al_2O_3)	1.969
Ferrous oxide (FeO)	25.790
Manganous oxide (MnO)	0.130
Nickel oxide (NiO)	0.549
Cobalt oxide (CoO)	0.049
Lime (CaO)	1.160
Magnesia (MgO)	16.920
Carbonic acid (CO_2)	0.271
Phosphoric acid (P_2O_5)	0.520
Water (H_2O)	2.799
Iron (metallic) (Fe)	10.400
Nickel (Ni)	0.949
Cobalt (Co)	0.020
Phosphorus (P)	0.092
Manganese (Mn)	0.119
Carbon (graphite) (C)	0.310
Sulphur	5.100
	102.846
Correction for O	2.54
	100.306

No barium, strontium, or zirconium could be detected.

The presence of water, though as a rule not expected, has before been noted in carbonaceous meteorites and in the present case at least is due to the oxidation and hydration of the sulphides and perhaps small amount of lawrencite. The mineral composition so far as determined by analysis and microscopic examination is:

	Per cent.
Silicate (enstatite)	74.42
Metal	11.50
Troilite	13.296
Oldhamite	0.596
Graphite	0.31
	100.122
Specific gravity	3.42

The stone is classed by Wülfing as a carbonaceous chondrite (Kc). Meunier places it in his Stawropolite Group.

So far as the author at this moment recalls, oldhamite has up to the present time been either found, or suspected to occur, in the meteoric stones of Allegan, Bishopville, Busti, Hvittis, Indarch, and St. Mark's. In the first two its presence has been shown only by chemical tests; in the other four its presence has as well been revealed by the microscope. How prevalent it may be in other stones remains to be seen and often much care and study must be devoted to its

search, as it is quite inconspicuous and until once seen difficult of recognition. It is of interest to note that thus far its presence does not seem to be characteristic of any particular class of stones, the Allegan being a chondritic tuff (Cco), Busti standing in a class almost by itself (Bu), Bishopville an almost purely pyroxenic stone (Chl), Hvittis a chrystalline "kugelchen" chrondite (Cck), Indarch a carbonaceous chrondite (Kc), and St. Mark's a chrystalline chondrite (Ck).